REMARKS

I.   Introduction

In view of the above amendments and the following remarks, reconsideration of the rejections and objections contained in the Office Action of October 1, 2008 is respectfully requested.

By this amendment claims 1-4 and 6 have been amended and claim 7-15 have been added. Claims 1-15 are now pending in the application. No new matter has been added by these amendments.

The entire specification has been reviewed and revised. Due to the number of revisions, the amendments to the specification have been incorporated into the attached substitute specification. For the Examiner's benefit, a marked-up copy of the specification and abstract indicating the changes made thereto is also enclosed. No new matter has been added by these revisions. Entry of the substitute specification is thus respectfully requested.

II.   Claim Objections

Claims 1, 3-4, and 6 were objected to for various informalities. The language of claim 1 at line 9 has been deleted; the remainder of the objections have been addressed as suggested by the Examiner. Withdrawal of the objections is respectfully requested.

III.   35 U.S.C. § 112

Claim 1 was rejected under 35 U.S.C. § 112, first paragraph, for failing to enable a sequence of operations which adjust the origin merely by displaying instructions to the operator. Claim 1 now recites "placing the positioning member in the first position" and "placing the positioning member in the second position." Amended claim 1 thus enables a sequence of operations which adjust an origin, and go beyond merely displaying instructions. Claim 9 also avoids this issue, reciting "displaying an indication to put the positioning member in the first position; rotating the second member...*while the positioning member is in the first position.*" (emphasis added.)

Claims 1, 2, and 4 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite. With respect to claim 1, the phrase "arranged to be attached" no longer appears in claim 1; withdrawal of this rejection is respectfully requested. Additionally, claims 1, 2, and 4 no longer include the "enabling" and "disabling" language highlighted in the indefiniteness rejection. It is submitted that the recitations of claims 1, 2, and 4 are sufficiently clear and definite; withdrawal of the rejections is respectfully requested.

IV.   35 U.S.C. § 103

Currently, claims 1-5 have been rejected under 35 U.S.C. § 103 as being unpatentable over Hidekazu (JP 2001-036879) in view of Jacobs et al (US 4,481,592); claim 6 has been rejected over Hidekazu in view of Jacobs in further view of Cordell et al. (US 6,996,456).

Claims 1 and 9 are patentable over Hidekazu and Jacobs, whether taken alone or in combination, for the following reasons. Claims 1 and 9 recite a method of adjusting an origin of an industrial robot comprising, in part, displaying an indication to put the positioning member in the first position, rotating a second member while a positioning member is in a first position, detecting whether or not a contact point of the second member is in contact with the positioning member, and if so, storing the position of the second member as the origin.

Hidekazu and Jacobs fail to disclose, whether taken alone or in combination, a step of displaying an indication, a step of detecting whether or not the contact point of the second member contacts the positioning member, or a step of storing the position of the second member, and thus cannot meet the limitations of claims 1 and 9. As acknowledged by the Examiner on Page 6, "Hidekazu is manual, with no mention of prompting," i.e. displaying. Modifying the Hidekazu reference, Examiner states "In Jacobs Fig. 26a, the automated calibration flow chart is shown including displaying directions to an operator." It appears that if any display is taught by Fig. 26a, it is a display of information numbered 1-13, including the month, day, year, etc. The only other mention of a step of displaying with reference to calibration is: "[a] display is made from which selections are available for loading the system." (Column 13, lines 9-10.) In other words, no passage in Jacobs could be found that would convey to a person of ordinary skill in the art that a prompt is given by displaying an indication. There is nothing to suggest that the steps

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for calibrating illustrated in Figure 26a, such as "Position Arm to Jig," "Limp/Rigid Key," and "Manually Attach Arm to Jig," are displayed. As a result, neither Hidekazu nor Jacobs meet the "displaying" limitation of claims 1 and 9. Hidekazu and Jacobs also fail to disclose a step of detecting whether or not the contact point is in contact with the positioning member. Again, Hidekazu is a manual process, as acknowledged by the Examiner.

Paragraph 0016 of Hidekazu appears to be the most relevant portion regarding this process, and no mention is made of any step of detecting or any means for detecting. Similarly, Jacobs discloses that the robotic arm is manually attached to a jig, no step of detecting a contact is disclosed. (See Figure 26a.) As a result, neither Hidekazu nor Jacobs meet the "detecting limitation of claim 1. Finally, Hidekazu does not disclose a step of "storing a position," as it is a manual process; Jacobs does not store a position, but rather stores a plurality of offsets. (See Jacobs Figure 26b.)

Claim 1 additionally requires a step of positioning the contact point at a predetermined position where the contact point does not contact the positioning member, and a second step of displaying an indication. As discussed above, neither Hidekazu nor Jacobs disclose displaying an indication, and thus cannot meet the second displaying step of claim 1. Additionally, Hidekazu does not disclose a step of positioning the contact point at a predetermined position. As a result, Hidekazu and Jacobs each fail to meet multiple limitations of claims 1 and 9.

Claims 2-8 and 10-15 depend directly or indirectly from claims 1 and 9, respectively, and are thus allowable for at least the reasons set forth above in support of claims 1 and 9.

In view of the foregoing amendments and remarks, inasmuch as all of the outstanding issues have been addressed, Applicants respectfully submit that the present application is in complete condition for issuance of a formal Notice of Allowance, and action to such effect is earnestly solicited.

Should any issues remain after consideration of the within response, however, the Examiner is invited to telephone the undersigned at his convenience.

If any fee beyond that submitted herewith, or extension of time is required to obtain entry of this Amendment, the undersigned hereby petitions the Commissioner to grant any necessary time extension and authorizes charging Deposit Account 23-0975 for any such fee not submitted herewith.

Respectfully submitted,

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December 22, 2008

DESCRIPTION

METHOD OF ADJUSTING ORIGIN OF INDUSTRIAL ROBOT

5 ### TECHNICAL FIELD

The present invention relates to a method of adjusting an origin of a joint of an industrial robot.

BACKGROUND OF THE INVENTION

10 In an operation of an industrial robot, an angle of a joint of a manipulator calculated by a processor, such as a CPU, for activating the joint is correlated to an actual angle of the joint. For this purpose, an origin, being a reference of a rotation of the joint is adjusted.

Fig. 6 shows a conventional apparatus for adjusting the origin disclosed 15 in Japanese Patent Laid-Open Publication No.2-180580. Member 611 rotates about rotation axis 620 with reference to member 612. Recess 613 is provided in the circumference of member 611 at a position corresponding to an origin. Adjusting device 630 detachable from member 612 is attached to the position corresponding to the origin. Adjusting device 630 includes 20 switch holder 615 fixed on member 612 at the position corresponding to the origin, switch 614 held by switch holder 615, straight bearing 616 mounted on switch holder 615, and sliding rod 617 movable guided by straight bearing 616. Switch 614 includes on/off movement 614A. End 617A of sliding rod 617, a positioning member, is engaged with on/off movement 614A. When 25 sliding rod 617 moves away from switch 614, other end 617B is put into recess 613 provided in member 611.

Fig. 7 shows another conventional apparatus of adjusting an origin

disclosed in Japanese Patent Laid-Open Publication No.2002-239967. Member 712 is coupled rotatably with member 711, so that surface 712A of member 711 contacts surface 711A of member 711. Detachable positioning member 722 is mounted detachably to mounting port 723 of member 711. 5 Member 712 has contact point 721 for contacting positioning member 722. Positioning member 722 is a positioning pin, while mounting port 723 is a tapped hole in which the positioning pin is screwed.

In these conventional adjusting apparatuses, an operation of the positioning member for contacting members 611 and 712 is not defined. An 10 operator practically activates an arm with a teaching device until the positioning pin contacts the members. ~~An operation of adjusting~~Adjusting the origin requires accuracy, thus increasing a work load on the operator and increasing a working time. An erroneous handling by the operator during adjusting the origin may hurt the position pin and the arm. The operator 15 ~~attached~~attaches and detaches the positioning member. If the operator fails to attach the positioning member, the origin is not adjusted properly. If the operator fails to detach the positioning member after ~~the~~adjusting ~~of~~ the origin ~~adjustment~~and activates the robot, the positioning member and the arm of the robot arm may be damaged.

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SUMMARY OF THE INVENTION

An industrial robot includes a first member, a positioning member arranged to be attached to the first member, a second member arranged to rotate relatively to the first member, and a first joint for coupling the first 25 member with the second member. The second member has a contact point arranged to contact the positioning member. An indication for requesting to enabling the positioning member to contact the contact point is displayed.

The second member rotates at the first joint relatively to the first member while the positioning member can contact the contact point. It is detected whether or not the contact point of the second member contacts the positioning member. A position of the second member is stored as an origin

5   when it is detected that the contact point of the second member contacts the positioning member.

This method prevents a possible failure of the attaching of the positioning member, and decreases a work load on an operator.

10   BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of an industrial robot according to an exemplary embodiment of the present invention.

Fig. 2A is a front view of a joint of the industrial robot according to the embodiment.

15   Fig. 2B is a cross sectional view of the joint shown in Fig. 2A at line 2B-2B.

Fig. 3 is a flow chart showing a method of adjusting an origin according to the embodiment.

Fig. 4A shows a teaching device according to the embodiment.

20   Fig. 4B shows a message displayed on the teaching device.

Fig. 4C shows a message displayed on the teaching device.

Fig. 4D shows a message displayed on the teaching device.

Fig. 4E shows a message displayed on the teaching device.

Fig. 5 is a front view of the joint of the industrial robot according to the

25   embodiment.

Fig. 6 shows a conventional apparatus for adjusting an origin.

Fig. 7 shows a conventional apparatus for adjusting an origin.

REFERENCE NUMERALS

101   Manipulator

102   Controller

5   103   CPU

104   Communication Unit

105   ROM

105A   Memory

106   RAM

10   107   Driver

108   Teaching Device

109   Tool

201   Arm (Second Member)

202   Arm (First Member)

15   203   Positioning Member

204   Contact Point

402   Display

403   Key Board

1201   Joint (Second Joint)

20   1202   Joint (First Joint)

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 is a schematic view of industrial robot 1 according to an exemplary embodiment of the present invention. Industrial robot 1

25   includes manipulator 101, tool 109 mounted on manipulator 101, controller 102 for controlling manipulator 101, and teaching device 108 used for activating manipulator 101 and controller 102. Tool 109 may be any one of

several various devices, such as a welding torch and an opening/closing hand, according to the ~~purpose~~ application.

Controller 102 includes CPU 103, communication unit 104 for communicating with teaching device 108, ROM 105 storing a program

5 allowing CPU 103 to operate, RAM 106 storing variable data, such as an operation program instructed by an operator and data for establishing an operating environment, and driver 107 for driving manipulator 101. ROM 105 and RAM 106 provide memory 105A.

Manipulator 101 includes arms 202 and 201 rotating with respect to

10 each other, base 1204, joint 1202 coupling arm 201 with arm 202, joint 1201 coupling arm 202 with base 1204, and joint 1203 coupling tool 109 and arm 201. Driver 107 of controller 102 controls the respective motors of joints 1201 to 1203 to drive manipulator 101.

An operation of industrial robot 1 will be described below. An operator

15 inputs an instruction for activating manipulator 101 to teaching device 108. The instruction input to teaching device 108 is sent to controller 102, and is sent to CPU 103 via communication unit 104. CPU 103 controls driver 107 according to the instruction for activating manipulator 101. The operator moves arms 202 and 201 of manipulator 101 to a predetermined position and

20 stance, and ~~have~~ has the position and stance stored in RAM 106 through a registering operation through teaching device 108. The above processes provide an operation program.

RAM 106 can store plural operation programs. In order to have industrial robot 1 ~~to~~ execute a predetermined task, such as welding and

25 handling, the operator uses teaching device 108 to select a operation program executing the predetermined task from the operation programs stored in the memory. CPU 103 reads and interprets the selected operation

program and controls manipulator 101 through driver 107 to have inductrial robot 1 execute the task.

CPU 103 calculates angles of respective joint axes of joints 1201 to 1203 of manipulator 101. Before industrial robot 1 operates according to the

5   operation program, the calculated angles are correlated to actual angles. That is, an origin, being a reference of the angle of each joint axis, is adjusted. A method of adjusting the origin of industrial robot 1 will be described below.

Fig. 2A is a front view of joint 1202. Fig. 2B is a cross sectional view of joint 1202 at line 2B-2B. Arm 201 rotates about joint axis 201A relatively to

10   arm 202. Positioning member 203 to be attached to arm 202 is a reference for adjusting the origin. As arm 201 rotates relatively to arm 202, contact point 204 contacts positioning member 203, thus setting an angle between arm 201 and arm 202 to a predetermined angle. Arm 201 is thus positioned with respect to arm 202, and the predetermined angle becomes the origin,

15   the reference. Arm 202 has hole 202A therein for accommodating positioning member 203. While being accommodated in hole 202A, positioning member 203 does not protrudes protrude from a surface, hence thereby not contacting arm 201 regardless of the position of arm 201.

Fig. 3 is a flow chart illustrating a method of adjusting the origin of

20   industrial robot 1. Fig. 4A shows teaching device 108. Teaching device 108 includes display 402 and keyboard 403 for allowing the operator to input the instruction and data. Display 402 displays messages read out by CPU 103 from ROM 105. Figs. 4B to 4E show the messages displayed on display 402.

The operator presses keyboard 403 of teaching device 108 to start an

25   origin-adjusting mode, and then, display 402 displays a message shown in Fig. 4A for indicating that the apparatus shifts to the origin-adjusting mode and for requesting the operator to select a joint axis to be adjusted from the

axes (Step 301).   The operator selects an axis where its origin is to be adjusted from axes of joints 1201 to 1203.   Here, the axis of joint 1202 is selected.

After the operator selects the axis to be adjusted, display 402 displays
5   an indication shown in Fig. 4B for requesting the operator to prevent positioning member 203 from contacting contact point 204 (Step 302).   That is, in order to start adjusting the origin, display 402 indicates that arm 201 is to be moved to a stand-by position.   Then, display 402 displays a message for having the operator cause positioning member 203 not to protrude, so
10   that positioning member 203 is not damaged by collision with contact point 204 or arm 201.   The operator checks the status of positioning member 203. If positioning member 203 protrudes from arm 202, the operator put positioning member 203 into hole 202A.   In the case that the robot includes positioning member 722 shown in Fig. 7, positioning member 722 is detached
15   from mounting port 723.

Then, the operator inputs an instruction through keyboard 403 for moving arm 201 to a stand-by position for adjusting the origin, by pressing start key 403A of keyboard 403.   A signal from keyboard 403 is sent from teaching device 108 to communication unit 104 of controller 102.   CPU 103
20   activates driver 107 in accordance with the program stored in ROM 105, and activates only joint 1202 selected at Step 301 (Step 303).

Fig. 5 is a front view of joint 1202 at Step 303.   According to the rotation at the axis of joint 1202, arm 201 rotates relatively to arm 202.   At Step 303, arm 201 moves to the stand-by position.   The stand-by position is
25   defined as a position at which contact point 204 of arm 201 does not contact positioning member 203 but just before contacting positioning member 203.

The stand-by position can be determined by angle A1 (see Fig. 1)

between arm 201 and arm 202. In the case that angle of 0° calculated by CPU 103 corresponds to angle A1 of 90°, the stand-by position can be, e.g. angle A1 of 100°, i.e., angle 10° calculated by CPU 103. Thus, the stand-by position can be referred to as a position at which positioning member does

5 not contact arm 201. The stand-by position, angle of 10°, i.e., angle A1 of 100°, is stored in ROM 105. Angle A1 used for determining the stand-by position is not necessarily precise. For example, the operator may position, with teaching device 108, one of arms 201 and 202 in a horizontal position while positioning the other of the arms in a vertical position, and then stores

10 the positions of arms 201 and 202 in RAM 106 as a provisional position corresponding to angle of 0°. The position corresponding to the angle of 0° may be roughly determined, and then the position may be used as the basis for setting roughly the stand-by position corresponding to the angle of 10°. The angle of 0° calculated by CPU 103 does not necessarily correspond to

15 angle A1 of 90°, but may correspond to other angle, such as 0°.

Instead, the stand-by position may be determined by the operator with teaching device 108. The operator positions contact point 204 of arm 201 near positioning member 203 with teaching device 108, so that contact point 204 may not contact positioning member 203. The operator ~~than store~~then

20 stores angle A1 (e.g. approximately 100°) between arms 201 and 202 in RAM 106 as the stand-by position. The stand-by position may not necessarily be precise as far as positioning member 203 does not contact arm 201. Therefore, the operator can determine the stand-by position easily.

When arm 201 reaches the stand-by position, display 402 displays an

25 indication for requesting to enable positioning member 203 to contact contact point 204 (Step 304). That is, display 402 displays a message shown in Fig. 4C for requesting the operator to execute an operation for having contact

point 204 contact positioning member 203. Acknowledging the message, the operator ~~take~~ takes out positioning member 203 from hole 202A in arm 202 ~~to have~~ such that positioning member 203 protrude from arm 202. If the robot includes positioning member 722 shown in Fig. 7, the operator put

5   positioning member 722 into the taped hole.

After causing positioning member 203 to protrude in accordance with the message shown in Fig. 4C, the operator presses keyboard 403 to instruct control device 102 to detect positioning member 203 (Step 305). At joint 1202, arm 201 rotates relatively to arm 201 in a direction directing contact

10   point 204 toward positioning member 203. Upon detecting contact point 204 of arm 201 contacts positioning member 203, controller 102 stops the rotation of arm 201.

A method by which controller 102 detects that contact point 204 ~~contacts~~ is in contact with positioning member 203 will be described below.

15   Contact point 204 contacts positioning member 203, ~~then~~ thereby stopping the rotation of arm 201. Motor 1202A for rotating arm 201 at axis 201A of joint 1202 is loaded with an extra torque greater than that for rotating arm 201. This causes motor 1202A to have a current flowing therein larger than that usually required for rotating arm 201. CPU 103 detects, via driver 107,

20   the current flowing in motor 1202A. When the detected current changes from a level smaller than a predetermined current to a level larger than the predetermined current, CPU 103 acknowledges that contact point 204 ~~contacts~~ is in contact with positioning member 203. Then, CPU 103 immediately stops the rotation at joint 1202, and stores the angle at this

25   moment in RAM 106 as the origin. In Fig. 2, contact point 204 of arm 201 contacts positioning member 203.

After controller 102 stops the rotation at joint 1202, display 402

displays a message shown in Fig. 4D for requesting the operator to execute an operation for restoring arm 201 to the stand-by position (Step 306).

Then, the operator activates keyboard 403 to allow only joint 1202 selected at Step 301 to start moving and return to the stand-by position determined at Step 303 (Step 307).

After arm 201 returns to the stand-by position, display 402 displays a message for requesting the operator to prevent positioning member 203 from contacting contact point 204 (Step 308). That is, display 402 displays a message shown in Fig. 4E for having the operator ~~to execute an operation for causing~~ cause positioning member 203 not to contact ~~contact~~ point 204. Upon acknowledging the message, the operator puts positioning member 203 in hole 202a in arm 202 as to have positioning member 203 not to protrude from arm 202. If the robot includes positioning member 722 shown in Fig. 7, positioning member 722 is detached from mounting port 723. Then, it is confirmed that positioning member 203 cannot contact arm 201 (Step 309).

An operation of confirming that positioning member 203 cannot contact arm 201 will be described below. When contact point 204 reaches and contacts positioning member 203 due to the rotation of arm 201, motor 1202A receives a torque larger than a torque for rotating arm 201, and then, has a current flowing therein larger than a current for rotating arm 201. If contact point 204 does not contact positioning member 203, motor 1202A has a current flowing therein for rotating arm 201, and not a current flowing therein larger than the current. Therefore, when CPU 103 confirms that motor 1202A has a current flowing not larger than a predetermined current, controller 102 judges that positioning member 203 does not contact arm 201. When detecting the current flowing in motor 1202A exceeds the predetermined current, controller 102 judges that positioning member 203

contacts arm 201.

When judging that positioning member 203 cannot contact arm 201, controller 102 (CPU 103) may display this status on display 402. When judging that positioning member 203 contacts arm 201, controller 102 may

5 display this status on display 402. Upon acknowledging this status, the operator confirms, at Steps 307 and 308, that the status of positioning member 203 ~~so~~ is such that positioning member 203 does not contact arm 201.

At Step 309, regarding a movable range of arm 201 needed for

10 confirming whether positioning member 203 contacts arm 201 or not, angle A1 may range from 80° to 100° if the origin is the position of positioning member 203 corresponding to angle A1 of 90°. The value 100° of angle A1 is stored in ROM 105 or RAM 106.

According to this embodiment, manipulator 101 automatically adjusts

15 the origin sequentially in accordance with the program stored in ROM 105 and the instruction sent through teaching device 108, thereby reducing a work loaded on the operator, and reducing an operation time.

The messages shown in Figs. 4A to 4E are displayed according to processes of adjusting the origin. This operation ~~has~~ causes the operator to

20 be aware of causing positioning member 203 not to protrude, that is, of disabling positioning member 203 to contact arm 201, thereby preventing damage to positioning member 203 and arm 201 ~~from damages~~.

According to this embodiment, the joint to be adjusted is selected, and the selected joint is activated for adjusting the origin. However, plural

25 joints may be selected. When confirming that positioning member 203 cannot contact the arm after the adjusting of the origin is completed, if positioning member 203 contacts the arm at least one of the selected joints,

display 402 may display this situation.

If a space where manipulator 101 is installed restricts movable ranges of arms 201and 202, it may be difficult to adjust all of respective origins at the joints are adjusted.   In this case, the origins at the joints may be

5   adjusted within available moving ranges.   The origins of the joints may be adjusted one by one.   Only joints requiring the adjustment of their origin may be adjusted.

INDUSTRIAL APPLICABILITY

10   A method of adjusting an origin for an industrial robot according to the present invention prevents an arm and a positioning member of the robot from damage.   This method is effective for reducing a work loaded on an operator and reducing a time for the adjustment.

ABSTRACT

An industrial robot includes a first member, a positioning member arranged to be attached to the first member, a second member arranged to rotate ~~relatively~~ relative to the first member, and a first joint for coupling the

5   first member with the second member.   The second member has a contact point arranged to contact the positioning member.   An indication for requesting to ~~enabling~~ enable the positioning member to contact the contact point is displayed.   The second member rotates at the first joint relatively to the first member while the positioning member can contact the contact point.

10   It is detected whether or not the contact point of the second member contacts the positioning member.   A position of the second member is stored as an origin when it is detected that the contact point of the second member contacts the positioning member.   This method prevents a possible failure of the attaching of the positioning member, and decreases a work load on an

15   operator.